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The Middle and Late Pleistocene glacial-interglacial succession of eastern Belarus

Irina E. PAVLOVSKAYA

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Detailed geological and palaeobotanical study of about 400 boreholes through Quaternary deposits in eastern Belarus has enabled the recognition of a number of Middle and Late Pleistocene interglacial sites and demonstrated the stratigraphical position of Alexandrian (Holsteinian) and Muravian (Eemian) Interglacial sediments. These stratigraphic markers are separated by a single glacial sequence, corresponding to the Dnieper (Saalian) Glaciation. This contradicts previous views suggesting the occurrence of two glaciations during the Late Middle Pleistocene in eastern Belarus (Dnieper and Sozh). The glacial sediments represent the recession phases of a glacial stage that may be correlated with the Drenthe Substage of the Saalian Glaciation.

Irina E. Pavlovskaya, Institute of Geological Sciences, National Academy of Sciences of Belarus, Kuprevich 7, 220141 Minsk, Belarus; e-mail: ipavl@ns.igs.ac.by *(received: November 29, 1999; accepted: February 14, 2000).*

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INTRODUCTION

The main problem of the Quaternary stratigraphy of Belarus concerns the subdivision of the Middle Pleistocene. Different concepts dealing with this problem are based mainly on palaeobotanical evidence. There are two main points of view concerning the number of glaciations in the Late Middle Pleistocene (Fig. 1). The first suggests two separate Dnieper and Sozh Glaciations, as proposed by Makchnach *et al.* (1970), Gurskij *et al.* (1986) and Matveyev (1990, 1995). The second suggests that only one glaciation occurred between the Alexandrian and the Muravian Interglacials (Velichkevich *et al.*, 1996). The latter subdivision is not widely used in geological mapping because, mainly advocated by palaeobotanists, it is based on isolated interglacial sections without sufficient analysis of their relationships with glacial sediments. Geologists engaged geological mapping cannot often find geological evidence of this stratigraphical concept and cannot apply it to the observed spatial distribution of sedimentary formations. It has become increasingly difficult to correlate geological maps, compiled by geologists who follow different stratigraphical subdivisions, particularly where glacial deposits possess very similar characteristics within areas where interglacial sediments have not been found. Biostratigraphic analysis of interglacial sediments alone is often insufficient to determine correctly the age of the interglacial and thereby of the associated glacial deposits. Precise relative age-dating of deposits requires analysis of spatial distribution, and facies relationships to be integrated with biostratigraphic information.

Here, the glacial deposits between two stratigraphic markers, the Alexandrian and Muravian Interglacial deposits, are analysed as regards their litho- and chronostratigraphic position within eastern Belarus. Special attention is paid to lateral variation away from key sites. In the past few years, new sections of interglacial deposits have been revealed during detailed geological mapping in eastern Belarus in 1995–1998, involving extensive drilling carried out by the enterprise "Geoservice" (Fig. 2). This area adjoins, on its western side, the Shklov Interglacial stratotype (Nizhninsky Rov) (Makchnach, 1971), and is a key area for investigations of the Sozh stratigraphic unit (Gurskij, 1974).

The area lies between the Dnieper and Sozh river valleys on the Shklov–Gorki morainic plateau and is characterised by a relatively flat relief of both the present and the pre-Quaternary surface. The Quaternary strata are commonly 70–80 m thick, reaching a maximum of 130 m. There is little evidence of glaciotectonic deformation or of winnowing by glacial meltwater. These are, favourable conditions for the preservation of interglacial sediments and numerous well-preserved and undisturbed sections of interglacial sediments have been found here

GLACIATIONS AND INTERGLACIALS	
after Gurskij *et al.* (1986)	after Velichkevich *et al.* (1996)
Poozierie	Poozierie
Murava	Murava
Sozh	Dnieper
Shklov	
Dnieper	
Aleksandriya	Aleksandriya
Berezina	Berezina
Beloviezha	Mogilev
	Nizhnin
	Beloviezha
Narev	Yaselda
	Korchevo
	Narev

Fig. 1. Chronostratigraphical subdivision of the Middle and Late Pleistocene in Belarus (interglacials are in grey)

(Pavlovskaya *et al.*, 1997*a*, *b*; Savchenko and Pavlovskaya, in press). Recently, over 20 new interglacial sites have been recognised.

INTERGLACIAL SEDIMENTS

Two interglacial sequences, separated by glacial deposits, have been distinguished in the area studied during the mapping; the older belongs to the Alexandrian Interglacial. Most Alexandrian sites are located in the central and southern parts of the area. Commonly these are lake deposits of gyttja, marl, occasionally silt; in some profiles peat is found at the top of the lacustrine sequence (Fig. 3a). In most cases, Alexandrian Interglacial sediments occur at 140–160 m a.s.l. in shallow incisions apparently formed by meltwater erosion cutting the underlying till (Novoselki, Chepelinka, Krivtsy, Dobraya, and others). These incisions are about 10 m in depth and they are generally filled with fine-grained sands, overlain by lake deposits containing organic matter. Commonly these deposits are 5–8 m thick, but reach up to 15 m at Smolka. The geological setting of these deposits indicate that there were systems of ravine lakes that existed throughout the Alexandrian Interglacial. These Alexandrian bog and lake sediments are buried beneath glaciolacustrine and glaciofluvial deposits or beneath till of the subsequent glaciation.

T. Yakubovskaya, T. Rylova, G. Simakova and I. Savchenko have undertaken palaeobotanical investigations of the lacustrine deposits. T. Yakubovskaya initially found abundant plant macrofossils that were generally rare in boreholes. In the Krivtsy, Novoselki and Dobraya sections, she identified macrofossils of *Ilex* sp., *Caulinia goretsky* and *Abies alba*, which together indicated an Alexandrian age (Pavlovskaya *et al.*, 1997*a*, *b*). This conclusion was confirmed by pollen evidence which unequivocally demonstrated a complete Alexandrian succession with high maxima of *Abies, Picea, Carpinus* and *Alnus*, together with Neogene relics such as *Tsuga, Juglans* and *Carya* (Pavlovskaya *et al.*, 1997*a*; Rylova *et al.*, 1999). The results of pollen investigations of the Dobraya section showed a complete vegetational succession extending to the beginning of the following glaciation (Rylova *et al.*, 1999), with a continuous vegetational succession and uninterrupted stratification at most sites.

Muravian sediments represent the younger interglacial sequence. Numerous sites with Muravian Interglacial deposits have been recognised north of the Alexandrian lake district area. These deposits are preserved in incisions directly cut into a till that overlies the Alexandrian Interglacial accumulations. The Muravian sediments occur at 170–180 m a.s.l., and their thickness does not exceed 7–8 m as a rule, but at isolated sites (Bobrovo, Kalinovka) they are up to 17 m thick. Some Muravian sections include peat lying directly on a till at the base of the interglacial sequence (Fig. 3b). Bog deposits are replaced successively by clayey, then calcareous gyttja, lacustrine sand and silt in the uppermost part of the sequence. Pollen, sedimentary and radiocarbon evidence at Azarichi (pollen analysis by I. Savchenko) and Kazyany (pollen analysis by V. Zernitskaya), indicate that lacustrine sedimentation in some kettle-hole depressions might have continued without any depositional break through the Muravian Interglacial and into Poozerian (Weichselian) time until the maximum advance of the last glaciation (Pavlovskaya and Zernitskaya, 1998; Savchenko and Pavlovskaya, in press). Numerous sections with Muravian and Poozerian sediments suggest lacustrine conditions throughout

Fig. 2. Location of cross-sections in Fig. 4 (lines with letters in white circles) and sites (black circles) mentioned in the paper

Early and Middle Poozerian time. The plant-bearing interglacial deposits are buried beneath sandy or sometimes silty lacustrine and slope sediments dating from Late Poozerian time.

The Muravian sites occur at a consistent altitude and in similar geological settings throughout the area, as do the Alexandrian deposits (see above). Thus, there are two buried lake fields in the area that originated in the marginal zones of two different glaciations. It should be emphasised that, despite the favourable preservational conditions for both the Alexandrian and Muravian Interglacial sediments, there is no evidence of any "warm" deposits which might correspond to the intervening Shklov Interglacial unit in the area studied (see Fig. 1). Velichkevich (1979) studied the plant macrofossils from the Nizhninsky Rov section, a regional stratotype for the Shklov Interglacial and considered this flora to be much older than that of the Alexandrian Interglacial, leading him to negate the concept of a Shklov Interglacial. Despite this, though, the subdivision of the younger Middle Pleistocene into a Dnieper Glaciation, a Shklov Interglacial and a Sozh Glaciation remained the prevailing concept for several decades.

GLACIAL SEQUENCE

The glacial deposits separating the Alexandrian and Muravian Interglacial sediments consist of glaciolacustrine and glaciofluvial sediments and tills. Natural exposures and boreholes spaced 1.5–2 km apart demonstrated the continuity of each lithological unit and provided information on texture, lithology, sedimentary structure and physical properties.

The till occurs at 150–170 m a.s.l., has distinctive and uniform lithological characteristics throughout the area and is a dominantly uniform, dense and pebbly loam, 15–20 m thick. A. Kazaryan (pers. comm.) has noted uniform physical properties as regards resistance, density, hardness and permeability. The physical and lithological characteristics of the till differ significantly from those of the Berezina (Elsterian) till which underlies the Alexandrian Interglacial sediments.

The sedimentary texture, structure and occurrence of the till indicate its subglacial origin. In general, the till is densely packed, with a horizontal lower contact lacking deformation and injections at its lower surface. The Novoselki and Dobryn sites only a series of small lenses 1–1.5 m long, composed of sandy material derived from the underlying glaciofluvial sediments, have been recognised within the till. However, long-axis orientations of these lenses correspond to those of the till fabrics. The latter orientation shows slight between-site variability of 10–15° and occasionally to 20°. These characteristics indicate that the till was deposited by lodgement under relatively fast moving ice.

The till can be traced continuously across almost the whole area (Fig. 4a, b), except in the south where glaciofluvial sediments (Fig. 4c) replace it. These consist of interbedded sands, gravels and silts which vary both laterally and vertically. They are often underlain by glaciolacustrine silts and clays, and overlain by fine-grained kame sands interbedded with silts. The glaciofluvial sediments include thin lenses of sandy till which probably formed subaqueously. The glaciofluvial-kame sequence has been found above local bedrock highs where the thickness of the Quaternary does not exceed 34 m and mostly consists of glaciofluvial deposits.

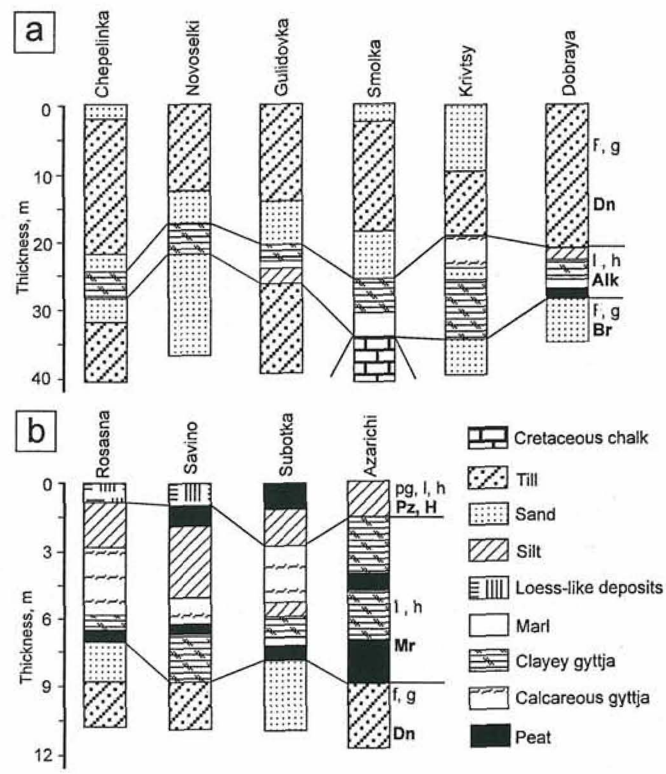

Fig. 3. Examples of Alexandrian (a) and Muravian (b) Interglacial sections

Genesis of sediments: glacial (g), glaciofluvial (f), periglacial polygenetic (pg), lake (l), bog (h); **age**: Br — Berezina Glaciation, Alk — Alexandrian Interglacial, Dn — Dnieper Glaciation, Mr — Muravian Interglacial, Pz — Poozerie Glaciation, H — Holocene

In spite of the above-mentioned structural differences in glacial deposits that occur between the Alexandrian and Muravian stratigraphic markers, they appear to be the same lithostratigraphic unit. This becomes evident if the setting and the palaegeographical factors that contribute to the properties of deposits are considered. The extensive Muravian lake district seems to have corresponded to the marginal zone of the previous glaciation, in the same way as the present lake districts mark the marginal regions of the last glaciation. Thus, mixed marginal deposits of glacial and glaciofluvial origin might be expected south of the Muravian lake district. The glaciofluvial sediments containing small lenses of reworked till, together with kame deposits, might reflect the melting and retreat of an ice front, most probably of relatively passive lateral margins where vast fields of dead-ice with local pools and meltwater channels were formed. The glaciofluvial deposits and overlying kame sediments were deposited from the melting of slow-moving or stagnant ice. The setting of these deposits vis-a-vis local bedrock elevations suggests that glacial dynamics depended on subglacial topography. The latter played an essential role in dividing ice into local lobes and conditioned the reductions in ice thickness and velocity, that led to ice margin stagnation.

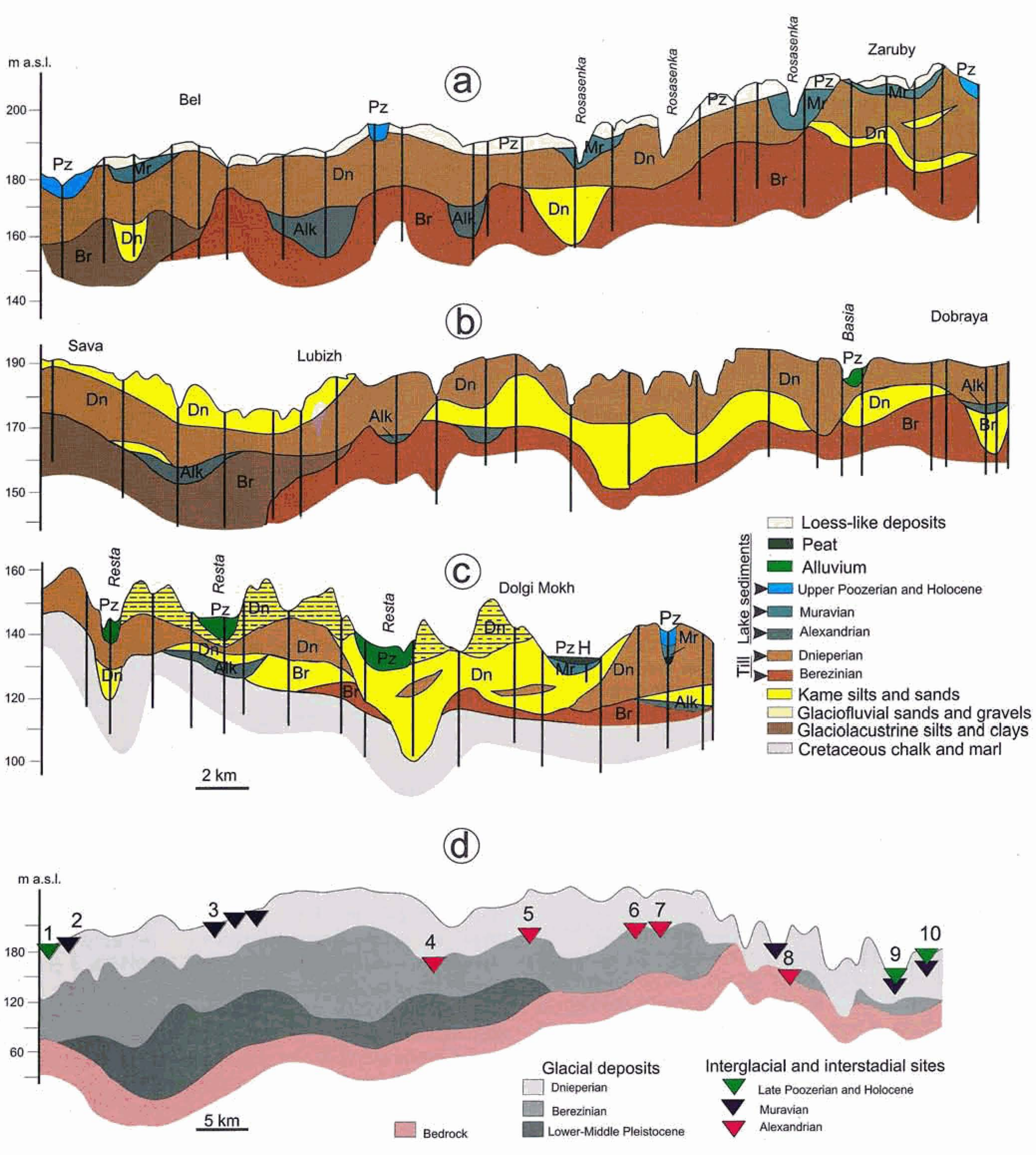

Fig. 4. Geological cross-sections a–c and generalised cross-section d; location see Fig.1

1 — Kazyany, 2 — Rosasna, 3 — Dobryn, 4 — Polna, 5 — Gulidovka, 6 — Krivtsy, 7 — Dobraya, 8 — Smolka, 9 — Subotka, 10 — Azarichi; for stratigraphic legend see Fig. 3

Thus, the deposits of mixed glacial-glaciofluvial origin conform to a marginal facies. In contrast, the deposition of the massive, dense till of the northern and central parts of the area probably represents sedimentation from moving ice as a lodgement till. The glacial successions thus reflect different phases of glacier recession.

FINAL REMARKS

Two assumptions have been made in considering the age of the glacial deposits. Firstly, the glacial deposits overlying Alexandrian sediments and underlying Muravian sediments are associated only with a glaciation which must be younger than the Berezina (Elsterian) Glaciation and older than the Poozerie (Weichselian) Glaciation. Secondly, despite the lithological variety of these deposits the glacial succession separating Alexandrian and Muravian sediments appears to represent a single depositional unit (Fig. 4d).

This glacial succession, including till, glaciofluvial, glaciolacustrine and kame deposits, seems to be associated with the Dnieper Glaciation and related only to a single glacial stage in the chronostratigraphic meaning of this term. The evidence does not confirm the notion of two successive glaciations (Dnieper and Sozh), at least in eastern Belarus.

However, these data do not sufficiently determine more precisely the stratigraphical equivalence of the glacial sequence. It might have been deposited during either the Drenthe or the Warte glacial episodes of the Saalian Glaciation. Nevertheless, the sedimentation history suggests deposition at the end of the Alexandrian Interglacial and at the beginning of the following glaciation without significant temporal interruption. In some kettle-hole sequences (e.g. Dobraya section) the Alexandrian pollen succession is superseded by an early glacial one and this also implies continuous sedimentation. On the other hand, the Muravian Interglacial sediments in the sites studied have a sedimentary break at their base in a number of sections. Therefore, there is a little evidence to suppose that the glacial sequence could be of Drenthe age. If intermediate interstadial sediments were to be located, then these may further constrain the precise stratigraphical age of the glacial succession.

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REFERENCES

GURSKIJ B. N. (1974) — Lower and Middle Quaternary stratigraphy in Belorussia. Nauka i Tekhnika. Minsk.

GURSKIJ B. N., MAKCHNACH N. A., LEVKOV E. A. and ILKEVICH G. I. (1986) — Stratigraphic scheme of the Quaternary deposits of Belarus. In: Problemy izuchenia zemnoi kory Belorussii i sopredelnych territorii (in Russian with English summary): 30–37. Doklady belorusskikh geologov na 27 sessii Mezdunarodnogo geologicheskogo Kongresa. Moskva. 1984. Nauka i Tekhnika. Minsk.

MAKCHNACH N. A. (1971) — Phases of the Antropogenic vegetation development in Belorussia (in Russian). Nauka i Tekhnika. Minsk.

MAKCHNACH N. A., LEVKOV E. A. and GURSKIJ B. N. (1970) — Stratigraphic subdivision of the Quaternary in Belorussia (in Russian with English summary). Dokl. AN Belarusi, **14** (1): 45–47.

MATVEYEV A.V. (1990) — History of the landform development in Belarus. Nauka i Tekhnika. Minsk.

MATVEYEV A. V. (1995) — Glacial history of Belarus. In: Glacial deposits in north-eastern Europe (eds. J. Ehlers, S. Kozarski and P. L. Gibbard): 267–276. Rotterdam-Brookfield.

RYLOVA T., PAVLOVSKAYA I. and SAVCHENKO I. (1999) — The age of the Pleistocene deposits of the Dobraya section (Eastern Belarus) (in Russian with English summary). Dokl. AN Belarusi, **43** (6): 94–97.

PAVLOVSKAYA I., SIMAKOVA G. and YAKUBOVSKAYA T. (1997*a*) — Alexandrian (Holsteinian) lacustrine deposits in eastern Belarus. In: Quaternary deposits and neotectonics in the area of Pleistocene glaciations. Abstract volume of the field symposium: 49–50. Minsk.

PAVLOVSKAYA I., SIMAKOVA G. and YAKUBOVSKAYA T. (1997*b*) — New sections with Alexandrian interglacial deposits in eastern Belarus (in Russian with English summary). Dokl. AN Belarusi, **41** (2): 95–99.

PAVLOVSKAYA I. and ZERNITSKAYA V. (1998) — Poozierskie peryglacjalne i interstadialne osady w profilu Kazjany (północno-wschodnia Białoruś). In: Paleogeografia górnego plejstocenu i holocenu wschodniej Polski i Białorusi: 39–40. Seminarium Polsko-białoruskie. Kraków.

SAVCHENKO I. and PAVLOVSKAYA I. (in press) — Muravian (Eemian) and Early Poozerian (Weichselian) deposits at Azarichi (eastern Belarus). Accepted for publication in: Proceedings of the 5 EPPC, Acta Palaeobot., Supp., 1999.

VELICHKEVICH F. Yu. (1979) — History of the Pleistocene flora in the middle part of the East-European Plain. In: Sovetskaya karpologia: 76–121. Nauka. Moscow.

VELICHKEVICH F., SANKO F., RYLOVA T., NAZAROV V., KHURSEVICH G. and LITVINIUK G. (1996) — Stratigraphic scheme of the Quaternary (Anthropogene) deposits in Belarus (in Russian). Strat. Geol. Correl., **4** (6): 75–87.